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ANALYSIS OF FIELD TRIALS WITH CIRCULAR AND RECTANGULAR VENTED LOBSTER TRAPS

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INTRODUCTION

The use of escape vents in lobster traps has long been recognized in most major lobster fisheries throughout the world as an effective means of reducing sublegal retention without compromising legal catch. Use of such vents is required by law in many of these fisheries. The Honolulu Laboratory initiated research in 1984 to ascertain the effectiveness of escape vents for use in the lobster trap fishery of the Northwestern Hawaiian Islands (NWHI).

At the time of the initial vent study, the fishery in the NWHI targeted primarily a single species of spiny lobster, *Panulirus marginatus*. All other species caught were considered incidental. The results of this research established that a specific size rectangular shape vent was extremely effective in releasing sublegal spiny lobsters, while retaining all legals. In many instances the legal spiny lobster catch rate was higher in the vented traps. However, as this research was being conducted, the use of a new lobster trap was introduced in the fishery which greatly increased the catchability of slipper lobster, *Scyllarides squammosus*. Within a short period of time the commercial landing of slipper lobster equaled that of spiny lobster. Unfortunately, the rectangular vent type allowed the escapement of a large percentage of this slipper lobster catch. The problem was confounded due to the lack of a minimum size restriction on slipper lobster.

Designing a vent that will be equally effective in allowing a high percentage of sublegal escapement without compromising legal retention for both species simultaneously presented a unique challenge, and little prior research had been completed dealing with this specific problem. The body dimensions of the two species are quite different. Slipper lobster are wider than high in body proportion, while the inverse is true of spiny lobster. This suggested that a circular vent that selected for slipper body width and at the same time spiny body height, might have potential for optimizing escapement. The observation of a Hawaiian lobster fisherman that slipper lobsters seem to have more difficulty than spiny lobsters in negotiating a small round opening, further supported this idea.

Additional laboratory tank trials conducted in March-April 1986 established that circular escape vents could indeed be a viable means of releasing specific size lobsters of both species. Based upon these results it was recommended that field trials be undertaken on a commercial vessel under actual working conditions in order to refine the selection size. A gradient of selection sizes was established on the basis of both the regression analysis performed on the morphometrics of the two species and the response surface model established from previous vent trails.

EXPERIMENTAL DESIGN

Four rectangular and four circular vent sizes were selected for evaluation in field trials onboard the commercial lobster vessel *Shaman*. The four rectangular vents had heights of 43, 45, 47, and 49 mm. The four circular vents had diameters of 60, 62, 65, and 67 mm. Both of these escape panels were made of No. 12 gauge aluminium plate cut into 335 x 113 mm rectangles. The circular vent panel had four equal size holes cut in the panel while the rectangular vent panel had a single 285 mm long slot cut in the center of the panel (Fig. 1). The small mesh black plastic Fathom Plus[1] traps used in the lobster fishery were modified with the vents. Tank tests suggested that the best position for the rectangular vents were near the top of the trap while the circular vents should be placed near the bottom of the trap. Thus the rectangular vented traps had two rectangular vent panels placed on opposite sides in the upper left hand corners while the circular vented traps had two circular vent panels placed on opposite sides in the lower right hand corners.

The FV Shaman typically sets 6 to 12 strings of traps for a total of 1,100 traps set each day. The number of traps per string varied from 50 to 250. There can be considerable variation in the catch rate of traps along a string and between traps of different strings. The variation in catch rate is typically minimum between adjacent traps on a string. Thus the experimental design used in the field trial compares vented and control traps set in adjacent sites on a string of traps to minimize the variation in catch per trap due to factors other than the venting. Specifically, on the Shaman, the NMFS researcher inserted three trap triplets at regular intervals on the Shaman's groundline. The three trap triplets always consisted of one rectangular vented trap, one nonvented control trap, and one circular vented trap. The spacing between the traps in the triplet was 50 m. Care was taken to insure that the control trap was inserted between the two vented traps and that none of the Shaman traps were inserted between the control and vented traps within a triplet. The rectangular and circular vent sizes were selected to provide a range of retention sizes which would cover the minimum legal spiny lobster tail width of 5.0 cm and a range of possible minimum sizes for slippers which have been proposed ranging from 5.2 to 5.6 cm. To facilitate the comparison of the catch rates of the two vent types with the same approximate retention size the rectangular and circular vents with the same relative sizes were paired by triplet. Thus the smallest rectangular vent (43 mm) and the smallest circular vent (60 mm) were fished in the same triplet, the next largest rectangular was fished in the same triplet with the next largest circular, and so forth. Each triplet (a nonvented control plus the vented pair) was fished for at least 1,800 total trap-nights. Fishing was done from August to November 1986, at Maro Reef, Gardner Pinnacles, Raita Bank, and Brooks Banks. A total of 5,353 legal spiny lobsters, 2,716 sublegal spiny lobsters, and 13,353 slipper lobsters were caught in the vented and control traps during the entire field trial.

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[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

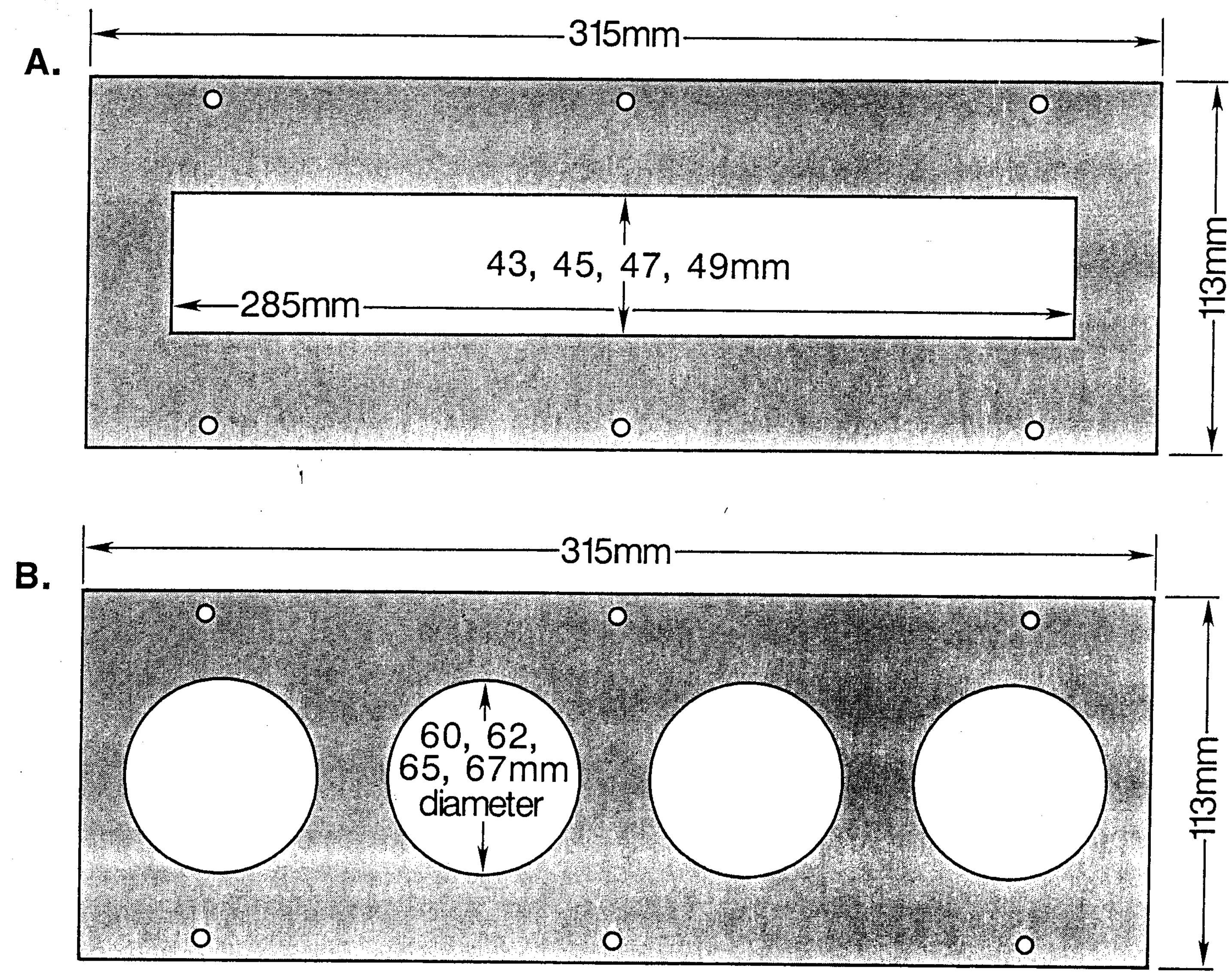

Figure 1.--Escape vent panels used during escape vent trials conducted aboard FV *Shaman* (A = rectangular; B = circular).

RESULTS

For each of the four triplets the mean catch per trap for the rectangular vent, control, and circular vent and the mean difference in catch per trap between the vented traps and control within a triplet for legal and sublegal size classes are given for spiny lobsters in Table 1 and for slipper lobsters in Table 2. For spiny lobsters a legal lobster is

Table 1.--Mean catch per trap by trap type and mean difference in catch per trap between trap types within triplets for spiny lobsters (* = $P \leq 0.05$; ** = $P \leq 0.01$; CPUE = catch per unit effort; Rec. = rectangular vent; Circ. = circular vent; control = nonvented traps).

Vent	No. of triplets	Rec.	Control	Circ.	Rec.-control	Circ.-control	Rec.	Control	Circ.	Rec.-control	Circ.-control
		Spiny legal lobster (TW≥5.0 cm) CPUE (number per trap)					**Spiny sublegal lobster CPUE (number per trap)**				
C-60 R-43	N=457	0.96	1.03	1.03	-0.06	0.0	0.36	0.46	0.32	-0.09	-0.14*
C-62 R-45	N=340	0.97	0.74	0.86	0.06	0.11	0.16	0.23	0.19	-0.07	-0.4
C-65 R-47	N=338	0.66	0.66	0.76	0.0	0.10	0.37	0.64	0.17	-0.27**	-0.47*
C-67 R-49	N=627	1.34	1.18	1.30	0.16*	0.12	0.51	1.75	0.29	-1.23**	-1.46*

defined as having a tail width which equals or exceeds 5.0 cm. In the case of slipper lobsters since no minimum size has been established, the impacts of the vented traps are evaluated for three hypothetical minimum legal slipper tail width sizes of 5.2, 5.4, and 5.6 cm. By comparing the differences in catch per trap between a vented trap and the control trap within a triplet, it is possible to reduce the large variation in trap catch between strings, days, and banks and have a powerful test of whether there is a difference in the catch per trap between control and vented traps. A paired t-test is the statistical test used to test these differences. The mean differences between a vented and the control trap within a triplet expressed as a percentage of the mean control catch per trap for spiny and slipper lobsters which summarizes Tables 1 and 2 are presented in Table 3 and Figure 2.

In general the vented traps substantially reduced the number of sublegal spiny and small slipper lobsters caught in the traps while the catches of legal spiny and medium and large slipper lobsters in the vented

Table 2.--Mean catch per trap by trap type and mean difference in catch per trap between trap types within triplets for slipper lobsters (* = P<0.05; ** = P<0.01; CPUE = catch per unit effort; Rec. = rectangular vent; Circ. = circular vent; control = nonvented traps).

Vent	No. of triplets	Rec.	Control	Circ.	Rec.-control	Circ.-control	Rec.	Control	Circ.	Rec.-control	Circ.-control
		Slipper legal lobster (TW≥5.6 cm) CPUE (number per trap)					**Slipper sublegal lobster CPUE (number per trap)**				
C-60 R-43	N=354	0.62	0.64	0.73	-0.03	0.08	0.29	0.56	0.45	-0.27**	-0.11
C-62 R-45	N=486	1.84	1.93	2.06	-0.09	0.13	0.40	0.93	0.64	-0.53**	-0.3**
C-65 R-47	N=504	3.71	3.52	3.66	0.19	0.14	0.59	2.54	1.13	-1.95**	-1.41*
C-67 R-49	N=315	0.50	0.74	0.67	-0.24**	-0.07	0.03	0.43	0.03	-0.40**	-0.40*
		Slipper legal lobster (TW≥5.4 cm) CPUE (number per trap)					**Slipper sublegal lobster CPUE (number per trap)**				
C-60 R-43	N=354	0.72	0.75	0.85	-0.03	0.10	0.18	0.45	0.32	-0.26**	-0.12*
C-62 R-45	N=486	2.05	2.15	2.26	-0.10	0.11	0.20	0.72	0.44	-0.52**	-0.28*
C-65 R-47	N=504	4.01	4.01	4.11	0.00	0.10	0.30	2.06	0.69	-1.76**	-1.37*
C-67 R-49	N=315	0.51	0.83	0.69	-0.31**	-0.14	0.02	0.34	0.01	-0.32**	-0.33*
		Slipper legal lobster (TW≥5.2 cm) CPUE (number per trap)					**Slipper sublegal lobster CPUE (number per trap)**				
C-60 R-43	N=354	0.84	0.87	0.95	-0.03	0.08	0.07	0.33	0.23	-0.26**	-0.10*
C-62 R-45	N=486	2.19	2.31	2.44	-0.12	0.13	0.05	0.55	0.26	-0.50**	-0.30*
C-65 R-47	N=504	4.12	4.54	4.53	-0.42*	-0.01	0.18	1.53	0.27	-1.34**	-1.26*
C-67 R-49	N=315	0.52	0.90	0.69	-0.39**	-0.21*	0.01	0.26	0.01	-0.25**	-0.26*

Table 3.--Mean difference between catch per trap between vented and control traps expressed as a percent of the control trap catch ($* = P \leq 0.05$, $** = P \leq 0.01$).

Vent	Rectangular (%)	Circular (%)	Rectangular (%)	Circular (%)
	Spiny lobster legal		**Spiny lobster sublegal**	
R-43, C-60	-6	0	-20	-30**
R-45, C-62	8	15	-30	-17
R-47, C-65	0	15	-42**	-73**
R-49, C-67	14*	10	-70**	-83**
	Slipper lobster legal (TW≥5.6 cm)		**Slipper lobster sublegal (TW <5.6 cm)**	
R-43, C-60	-5	13	-48**	-20
R-45, C-62	-5	7	-57**	-32**
R-47, C-65	5	4	-77**	-56**
R-49, C-67	-32**	-10	-93**	-93**
	Slipper lobster legal (TW≥5.4 cm)		**Slipper lobster sublegal (TW <5.4 cm)**	
R-43, C-60	-4	13	-58**	-27**
R-45, C-62	-5	5	-72**	-39**
R-47, C-65	0	3	-85**	-67**
R-49, C-67	-37**	-17	-94**	-97**
	Slipper lobster legal (TW≥5.2 cm)		**Slipper lobster sublegal (TW <5.2 cm)**	
R-43, C-60	-3	9	-79**	-30**
R-45, C-62	-5	6	-91**	-55**
R-47, C-65	-9*	0	-88**	-82**
R-49, C-67	-43**	-23**	-96**	-100**

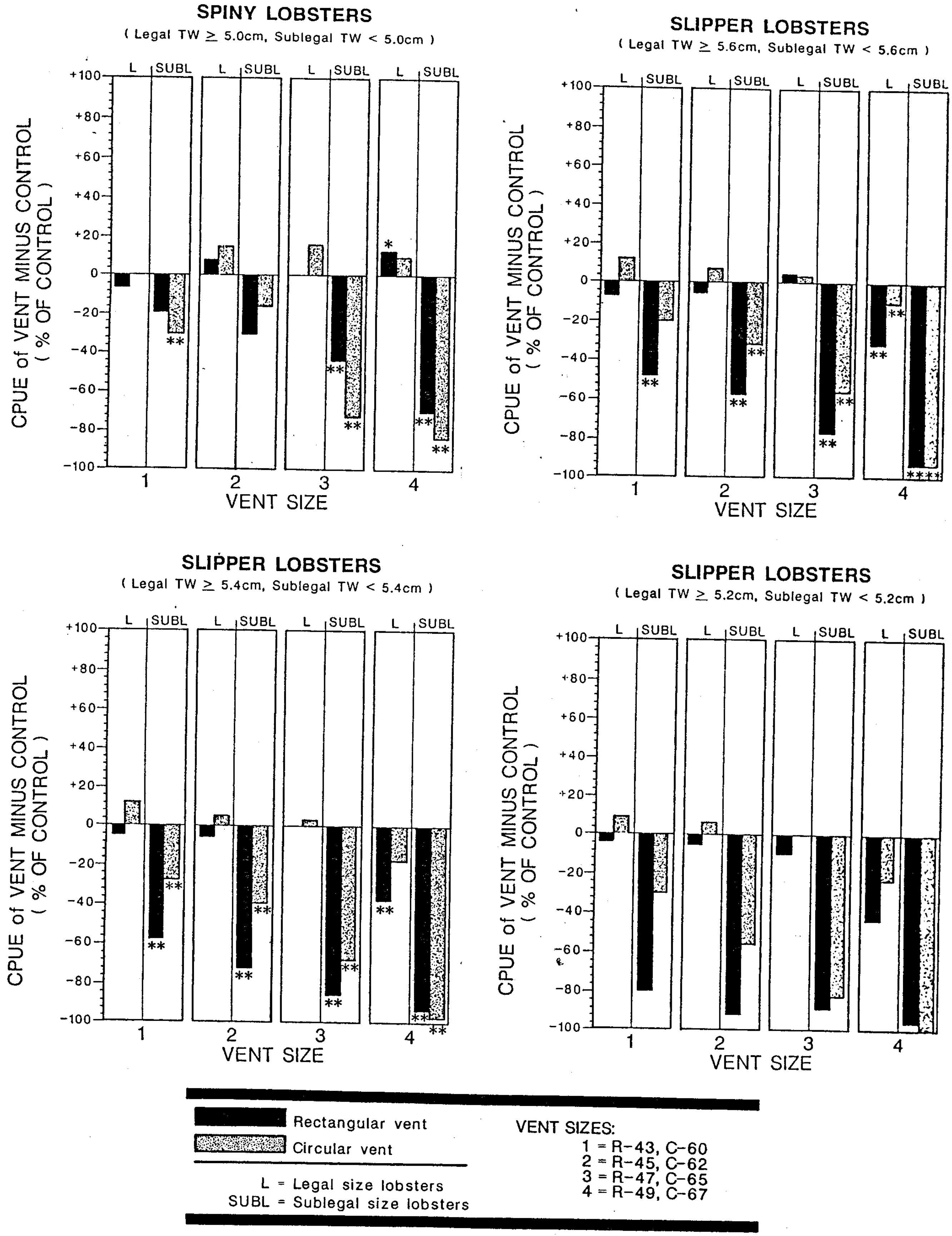

Figure 2.--The CPUE of vent traps minus control traps expressed as a percent of control trap CPUE for slipper and spiny lobsters. Based on values given in Table 3 (* = P<0.05, ** = P<0.01).

traps were comparable to catches in the control traps. The escapement of sublegal spiny and small slipper lobsters increased as vent size increased (Table 3; Fig. 2).

The circular vents perform better than the rectangular vents in maximizing sublegal escapement for both spiny and slipper sublegals while minimizing loss of both slipper and spiny legals. For example, to achieve a sublegal escapement from a rectangular trap which is less than the control by 70% of the control it is necessary to use the largest rectangular vent with a height of 49 mm. However, this vent reduces the legal slipper CPUE from 32 to 43% of the control, depending on the minimum legal slipper size. If a smaller rectangular vent is used the retention of sublegal spiny lobsters increases substantially. However, the circular 65 mm diameter vent achieves a reduction in sublegal spiny CPUE by 73% of the control CPUE, reductions of slipper sublegal CPUE's by 56 to 82% of the control, depending on the minimum legal tail width, and this vent produces legal spiny and slipper legal CPUE's which equal or exceed the control traps (Table 3).

While the selection of the circular vent over the rectangular vent is easy, the choice of the circular vent diameter is a more difficult decision which requires weighing the relative importance of sublegal escapement against retention of legal lobsters. For example, if the minimum legal tail width for slippers is 5.4 cm then a circular vent with diameter 67 mm provides almost complete escapement of sublegal slippers but may produce a 17% reduction in legal CPUE. The smaller 65 mm diameter vent offers a slight gain in legal CPUE over the control but only reduces sublegal CPUE by 67% of the control (Table 3).

Since the landings of slippers and spiny lobsters were about equal in 1985 and 1986, it is reasonable to consider the combined slipper and spiny CPUE as a function of vent size and slipper minimum tail width. The values in Table 3 are averaged for slipper and spiny lobsters to give a measure of the average performance of the circular vent traps for the combined catch (Table 4).

When the minimum tail width for slippers is 5.6 cm, the circular 67 mm vent is ideal since there is no loss in combined slipper and spiny legal CPUE relative to the control while the vented traps reduce the combined retention of sublegals by 88% of the control sublegal CPUE for the two species combined (Table 4). Even when the minimum legal tail width for slippers is 5.4 or 5.2 cm, the circular 67 mm diameter vent performs very well since it only allows a very slight (statistically not significant) reduction in the combined legal CPUE while reducing sublegal retention of the combined species by at least 90% of the control.

Should it be necessary to interpolate the values in Tables 3 and 4 for the circular vents for intermediate vent sizes or minimum tail widths two predictive equations have been derived.

Table 4.--The performance of circular vented traps relative to control traps for the combined slipper and spiny lobster CPUE. Values in this table are the average of the slipper and spiny lobster values from Table 3. (* = $P \leq 0.05$, ** = $P \leq 0.01$).

Vent	Spiny and slipper legal (%)	Spiny and slipper sublegal (%)
	Slipper legal TW≥5.6 cm	
C-60	6.5	-25.0
C-62	11.0	-24.5
C-65	9.5	-64.5**
C-67	0.0	-88.0**
	Slipper legal TW≥5.4 cm	
C-60	6.5	-28.5**
C-62	10.0	-28.0**
C-65	9.0	-70.0**
C-67	-3.5	-90.0**
	Slipper legal TW≥5.2 cm	
C-60	4.5	30.0**
C-62	10.5	-36.0**
C-65	7.5	-77.5**
C-67	-6.5	-91.5**

A predictive equation for slipper lobsters relating the difference between the catch rate of the circular vented and control traps expressed as a percent of the control catch rate (Y) can be described as a function of the legal minimum size (MS) expressed in millimeters, the vent size (VS) expressed in millimeters, and a dummy variable (C) which takes the value 1 if Y refers to legal lobsters and 0 if Y refers to sublegal lobsters as follows:

$$Y = 361.6 - 9.4(VS) + 3.3(MS) - 374.4(C) + 6.8(C)(VS) \quad (R^2 = 0.96)$$

A predictive equation for the combined catch of slipper and spiny lobster relating the difference between combined catch rate of the circular vented and control trap expressed as a percentage of its control catch rate (Table 4) (Y) as:

$$Y = 567.1 - 11.2(VS) + 1.6(MS) - 594.3(C) + 10.3(C)(VS) \quad (R^2 = 0.98)$$

The economic benefits to the fishery from the use of escape vents may be substantial. In 1986, there were 310,000 sublegal spiny lobsters reported caught and released in the NWHI. If just 20% of these suffer mortality from handling, exposure, displacement, etc., due to capture and release, this amounts to 62,000 lobsters. If the use of escape vents effectively eliminates this mortality and 80% of these 62,000 lobsters are subsequently captured as legal lobsters by the fishery, then at $5.00/lobster, the annual benefit to the fishery from the use of escape vents is $248,000. The value of slipper lobsters saved by the use of escape vents will also be substantial. Further the fishery will benefit from the spawning contribution of these lobsters before they are caught by the fishery and the vents will greatly reduce sorting work on the vessels.

ACKNOWLEDGMENTS

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